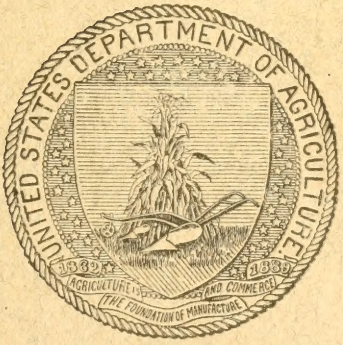
SB
273
G25

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 143.
B. T. GALLOWAY, *Chief of Bureau.*

PRINCIPLES AND PRACTICAL METHODS OF CURING TOBACCO.

BY
W. W. GARNER,
PHYSIOLOGIST, TOBACCO INVESTIGATIONS.

ISSUED FEBRUARY 16, 1909.



LIBRARY OF CONGRESS

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

SHOUT
SHARE
IT

Class SB273

Book G25

12
178

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 143.

B. T. GALLOWAY, *Chief of Bureau.*

8

PRINCIPLES AND PRACTICAL METHODS OF CURING TOBACCO.

BY

W. W. GARNER,

PHYSIOLOGIST, TOBACCO INVESTIGATIONS.

1174
353

ISSUED FEBRUARY 16, 1909.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1909.

copy 2

SB273
G25

BUREAU OF PLANT INDUSTRY.

Physiologist and Pathologist, and Chief of Bureau, Beverly T. Galloway.
Physiologist and Pathologist, and Assistant Chief of Bureau, Albert F. Woods.
Laboratory of Plant Pathology, Erwin F. Smith, Pathologist in Charge.
Fruit Disease Investigations, Merton B. Waite, Pathologist in Charge.
Laboratory of Forest Pathology, Haven Metcalf, Pathologist in Charge.
Cotton and Truck Diseases and Plant Disease Survey, William A. Orton, Pathologist in Charge.
Pathological Collections and Inspection Work, Flora W. Patterson, Mycologist in Charge.
Plant Life History Investigations, Walter T. Swingle, Physiologist in Charge.
Cotton Breeding Investigations, Archibald D. Shamel and Daniel N. Shoemaker, Physiologists in Charge.
Tobacco Investigations, Archibald D. Shamel, Wightman W. Garner, and Ernest H. Mathewson, in Charge.
Corn Investigations, Charles P. Hartley, Physiologist in Charge.
Alkali and Drought Resistant Plant Breeding Investigations, Thomas H. Kearney, Physiologist in Charge.
Soil Bacteriology and Water Purification Investigations, Karl F. Kellerman, Physiologist in Charge.
Bionomic Investigations of Tropical and Subtropical Plants, Orator F. Cook, Bionomist in Charge.
Drug and Poisonous Plant and Tea Culture Investigations, Rodney H. True, Physiologist in Charge.
Physical Laboratory, Lyman J. Briggs, Physicist in Charge.
Agricultural Technology, Nathan A. Cobb, Crop Technologist in Charge.
Taxonomic and Range Investigations, Frederick V. Coville, Botanist in Charge.
Farm Management, William J. Spillman, Agriculturist in Charge.
Grain Investigations, Mark Alfred Carleton, Cerealist in Charge.
Arlington Experimental Farm and Horticultural Investigations, Lee C. Corbett, Horticulturist in Charge.
Vegetable Testing Gardens, William W. Tracy, sr., Superintendent.
Sugar-Beet Investigations, Charles O. Townsend, Pathologist in Charge.
Western Agricultural Extension, Carl S. Scofield, Agriculturist in Charge.
Dry-Land Agriculture Investigations, E. Channing Chilcott, Agriculturist in Charge.
Pomological Collections, Gustavus B. Brackett, Pomologist in Charge.
Field Investigations in Pomology, William A. Taylor and G. Harold Powell, Pomologists in Charge.
Experimental Gardens and Grounds, Edward M. Byrnes, Superintendent.
Foreign Seed and Plant Introduction, David Fairchild, Agricultural Explorer in Charge.
Forage Crop Investigations, Charles V. Piper, Agrostologist in Charge.
Seed Laboratory, Edgar Brown, Botanist in Charge.
Grain Standardization, John D. Shanahan, Crop Technologist in Charge.
Subtropical Garden, Miami, Fla., P. J. Wester, in Charge.
Plant Introduction Garden, Chico, Cal., W. W. Tracy, jr., Assistant Botanist in Charge.
South Texas Garden, Brownsville, Tex., Edward C. Green, Pomologist in Charge.
Farmers' Cooperative Demonstration Work, Seaman A. Knapp, Special Agent in Charge.
Seed Distribution (directed by Chief of Bureau), Lisle Morrison, Assistant in General Charge.

Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

Tobacco Investigations.

SCIENTIFIC STAFF.

A. D. Shamel, *Physiologist;* W. W. Garner, *Physiologist;* and E. H. Mathewson, *Crop Technologist, jointly in charge.*

W. M. Hinson, W. W. Green, and G. W. Harris, *Crop Technologists.*
J. B. Stewart and Otto Olson, *Tobacco Experts.*
J. B. Norton, *Physiologist.*
H. Woosley, R. P. Cocke, J. E. Blohm, H. K. Hayes, and D. E. Brown, *Special Agents.*
C. L. Foubert, *Chemist Aid.*
B. G. Anderson, *Collaborator.*

FEB 27 1909
D. of D.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 28, 1908.

Sir: I have the honor to transmit herewith a manuscript entitled "Principles and Practical Methods of Curing Tobacco," and recommend that it be published as a bulletin of the series of this Bureau.

The proper management of the curing barn requires some knowledge of the physiological changes which are taking place in the curing process. There is a rapidly increasing demand for such information. For this reason the bulletin has been divided into two parts, one discussing the principles of curing and the second the practical methods of curing based on the principles discussed in the first part.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

PART I.—PRINCIPLES OF CURING TOBACCO. Page.

Introduction ... 7

Changes in the composition and properties of the leaf which take place in the curing process ... 8

The ripening of tobacco ... 9

Curing the picked leaves compared with curing on the stalk ... 10

The air-curing process ... 12

First stage of air-curing ... 13

Second stage of air-curing ... 14

The most favorable conditions for air-curing ... 15

Pole-sweat, or house-burn ... 17

Air-curing as affected by heat and ventilation ... 18

Available methods of applying artificial heat ... 20

Modifications of the air-curing process ... 21

The flue-curing process ... 22

Changes in the composition and properties of the leaf ... 22

Conditions affecting the rate of cure ... 23

Management of flue-curing ... 24

Curing tobacco with open fires ... 25

PART II.—PRACTICAL METHODS OF CURING AS APPLIED TO THE VARIOUS TYPES OF TOBACCO.

Cigar tobaccos ... 27

Construction of the barn for curing cigar tobacco ... 27

Harvesting cigar tobacco ... 30

Curing cigar tobacco ... 33

Stripping and assorting cigar tobacco ... 35

Shade-grown cigar-wrapper leaf ... 36

Management of the curing barn ... 38

Burley tobacco ... 39

Harvesting Burley tobacco ... 40

Curing Burley tobacco ... 40

Assorting and packing Burley tobacco ... 40

Sun-cured tobacco ... 41

Yellow tobacco ... 41

Construction of the barn for curing yellow tobacco ... 41

Harvesting yellow tobacco ... 44

Curing yellow tobacco ... 45

Handling yellow tobacco after curing ... 46

Heavy export tobaccos ... 47

Harvesting export tobacco ... 48

Curing export tobacco ... 48

Handling export tobacco ... 49

Perique tobacco ... 50

Index ... 53

ILLUSTRATIONS.

Page.

FIG. 1. Type of barn used in northern cigar-tobacco districts, showing the arrangement of horizontal ventilators 29
2. Type of barn used in southern cigar-tobacco districts, showing the arrangement of ventilators 30
3. Tobacco field, showing the method employed in spearing plants on a lath, with the hurdle used for supporting the latter during the operation 32
4. The best form of wagon rack for hauling plants to the curing barn 32
5. A very convenient wagon rack for hauling baskets of picked leaves to the curing barn 37
6. The interior of a cigar-tobacco barn, showing the arrangement of tier poles and the method of hanging picked leaves 38
7. Type of tobacco barn used in the Burley district of Kentucky 39
8. A typical log barn used in curing yellow tobacco, showing the ventilator in the gable and the outside portions of the heating system 42
9. Sketch showing the arrangement of furnaces and flues in a barn adapted for curing yellow tobacco 43
10. Stick with wires used in the yellow-tobacco districts for hanging picked leaves in the curing barn 45

B. P. I.—430.

PRINCIPLES AND PRACTICAL METHODS OF CURING TOBACCO.

PART I.—PRINCIPLES OF CURING TOBACCO.

INTRODUCTION.

The tobacco plant is very sensitive to the surroundings under which it is forced to grow. Its physical characters, as well as its composition, are greatly influenced by soil, climate, fertilizers, and the treatment which it receives at the hands of the growers. The quality of the finished product, moreover, depends to a large extent on the care and skill which are displayed in the curing and fermentation processes. Again, tobacco is subject to the attacks of numerous insect enemies and to fungous diseases in the seed bed, in the field, in the curing shed, in the packing house, and even after it leaves the hands of the manufacturer. Hence, it will readily be seen that the greatest care and skill must be used by the grower, as well as by the packer and manufacturer, in order to turn out a first-class finished product. There are, in fact, few, if any, other important crops the values of which are so dependent on the painstaking care, skill, and good judgment of the producer. And of the various factors entering into the successful production of a superior quality of tobacco, none is more important than the proper management of the curing process, for a crop of the highest promise may be irretrievably damaged in the curing barn under unfavorable conditions.

The tobacco industry has become highly specialized in this country and has been made the subject of a great deal of study and experimentation on the part of growers; but although the practical side of the industry has attained its highest development in this, its native, country, it has not received anything like the attention the subject merits at the hands of our scientific investigators. This is particularly true of the curing process, for while the process involves many complex changes in the composition and properties of the leaf which greatly affect its commercial value these changes are for the most part imperfectly understood. As a natural result,

progress in the development of satisfactory practical methods has been slow, and this phase of the industry is, as a whole, still in a comparatively crude state.

Some of the more important principles of successful curing are well established, however, and it is to the interest of every grower to acquaint himself as far as practicable with the nature of these fundamental facts. Of course, long experience is essential in this as in other features of tobacco growing, but it is also undoubtedly true that the experienced operator will be the better able to meet the various unexpected contingencies which are sure to arise from time to time by carefully studying the underlying principles governing the cure. The more thoroughly the grower understands the nature of the changes going on in the leaf during the curing and the most favorable conditions for bringing about these changes, the easier will it be for him to adopt proper methods for securing these essential conditions. The first portion of this bulletin, therefore, is devoted to a discussion of those changes which take place in the curing process and the most favorable conditions for accomplishing those results. In this discussion the subject-matter has been freed from unnecessary technicalities, so that it is hoped it may be read with interest and profit by the practical grower. It is further hoped that the suggestions made concerning many important phases of the subject which have not as yet been worked out may serve to direct the attention of intelligent and progressive growers to the need of studying further some of these problems. Following this discussion of the subject of curing from the theoretical standpoint will be found a rather complete, though concise, description of the methods now actually in use for curing the various types of leaf produced in the different tobacco sections.

CHANGES IN THE COMPOSITION AND PROPERTIES OF THE LEAF WHICH TAKE PLACE IN THE CURING PROCESS.

If a sample of tobacco taken from the field at the usual time of harvesting were dried out rapidly in an oven and manufactured into appropriate forms for smoking or chewing, it would scarcely be recognized as tobacco by the consumer. Above all else, the grower should keep in mind the fact that curing is not simply the drying out of the leaf but involves a number of other important changes in composition, which can only be brought about under certain definite conditions. There are several different classes of tobacco, each adapted to certain trade requirements, and the details of the curing are variously modified to suit the class to which the finished product is to be assigned. By modifying the conditions of curing, some of the important properties of the leaf are forced to develop along

quite different lines. Many of the most valuable qualities of one type may not be at all desirable in another type, so that it is important that the grower first acquaint himself with the trade requirements of the particular type which he can produce to the best advantage, and then ascertain as nearly as possible the most favorable conditions of curing for developing the fine qualities of that type.

THE RIPENING OF TOBACCO.

Soon after the leaves of the tobacco plant reach maturity they undergo marked changes in color and other properties and these changes constitute the ripening process. The young growing leaf has an intense green color, showing that it is quite rich in the nitrogenous constituents which go to make up the living or vital part of the leaf and which are active in building up the food supply of the plant. At about the time the leaves of the plant as a whole have reached their maximum power of elaborating the food supply the flower head begins to develop. This food supply, consisting of starch and other similar substances, is carried from the leaf into the seed head to furnish the necessary food for the development of the seed. This accomplished, the leaves have completed their full task and they now pass into a period of gradual decay. In practice, however, the plant is topped, so that the seeds are not allowed to develop. Making a last effort to reproduce itself, the plant now sends out secondary shoots or suckers, but these, too, are removed by the grower. Under these circumstances, the food built up by the leaves is not carried away to other parts of the plant but accumulates in the leaves themselves. The result is that both the size and body of the leaf are increased.

The principal indication that the above-mentioned processes are taking place is a decided change of color. When the reserve food supply of the mature leaf is no longer required for the nourishment of other parts of the plant it is deposited in the leaf tissue in the form of starch granules, while the green coloring matters are dissolved and carried to the younger, growing parts. This interchange causes the appearance of the light-tinted flecks so characteristic of the ripe leaf. Moreover, the accumulation of the starch granules in the leaf causes it to become brittle, so that it snaps when folded between the fingers, another characteristic sign of ripeness. Now the replacement of the complex nitrogenous constituents, including the green coloring matter, by the starchy matter has a most important effect on the color, flavor, elasticity, and finish of the leaf. Indeed, much of the success in curing tobacco depends on harvesting it just at the right time, when it is neither too ripe nor too green. Thus, in the case of cigar tobacco, the brightest, clearest, brown colors are

obtained when the leaves are harvested just before they would be called fully ripe. If harvested before this period the colors will be dull or "muddy" and too dark, because they still contain too much of the green coloring matters with which the brown coloring substances are closely associated. On the other hand, if the leaves are allowed to become too ripe, the colors will be uneven and mottled and lacking in freshness because of a deficiency of the green coloring matters. For the same reasons a green leaf after curing will be tough and leathery, while an overripe one will be "strawy" and lifeless to the touch. Finally, since the materials which develop the flavor and aroma are derived from the green nitrogenous compounds, the fully ripe leaf will be deficient in these qualities, while the green leaf will possess them much more highly developed.

It is evident, then, that the lower, fully mature leaves of the plant when moderately ripe will be best suited for the production of cigar wrappers bright in color and having the necessary elasticity but neutral in flavor, while the upper leaves harvested before they have fully matured will give the best fillers, having the required flavor and aroma but being much darker in color than the wrappers. In curing the bright yellow tobacco it is necessary that the leaf be fully ripe, for the content of the green coloring matter must be reduced to the minimum consistent with the required toughness in order to obtain the cured leaf free from green or brown discoloration.

CURING THE PICKED LEAVES COMPARED WITH CURING ON THE STALK.

The details of the curing process are variously modified to suit the requirements for the different classes of tobacco, but whatever this subsequent treatment may be there are two general methods of harvesting the crop and arranging it in the barn. In the one case the leaves are picked from the stalk as they ripen and are arranged on strings or sticks suitable for hanging in the curing shed. In the other method the leaves are not removed from the stalks, but the latter are cut off near the ground and suspended in an inverted manner in the barn. Of course all the leaves on the plant do not ripen at the same time, so that the tobacco is harvested at such time as will give the greatest number of the best leaves at the proper stage of ripeness. This necessitates a considerable sacrifice in both bottom and top leaves, since the former are overripe and the latter still immature, but the method saves labor.

There has been much discussion from a practical as well as from a scientific standpoint as to the relative merits of the two methods, and each has its advantages and its disadvantages. Both give satisfactory results when properly carried out, and the question as

to which is the better in any given case must be decided largely by the local conditions, such as the amount and kind of the labor supply, the barn space available, and the like. In the end the problem resolves itself into the question of the relative value of the crop to be cured, and nearly all of the highest priced tobaccos are now being cured by the method of picking the leaves, generally spoken of as "priming." This is more expensive than the method of curing on the stalk, but possesses the great advantage that it is possible to harvest all the leaves just at the right stage of maturity, and this fact becomes important when the tobacco is produced under a highly intensive system involving a large outlay of capital.

Although, as has been said, both methods are capable of giving good results, there are undoubtedly differences in the character of the cured product as obtained in the two processes. To understand the differences brought about by these two methods of curing, we must remember that the leaves and the stalks remain alive for several days or even weeks after harvesting, depending on the conditions which prevail in the curing barn. They are enabled to remain alive so long as they retain sufficient moisture by means of the reserve food supply which has been stored up. The outer edges of the leaf are first killed by loss of moisture, and the unused portion of the food supply is withdrawn toward the midrib, which is the last part of the leaf to die. When the leaves are picked from the stalk, of course this transfer of the food materials can get no farther than the midrib of the leaf, but when the leaf remains attached to the stalk these food materials pass into the stalk to keep this alive and to supply nourishment to the young suckers which are struggling to develop.

Every one who has cured cigar tobacco on the stalk must have been impressed by the remarkable vitality of the stalk itself as well as of the young suckers, whereby they remain alive for many weeks before the point of starvation is reached. On account of the water contained in the stalk, which gradually passes into the leaf to replace that lost by evaporation, the leaf under these conditions remains alive for a much longer period than when separated from the stalk. Since a portion of the reserve food supply of the leaf is transported into the stalk when the leaf is left attached to the stalk, and since, further, the leaf remains alive for a longer period under these circumstances, and so itself uses up more of its accumulated food, we should not be surprised that leaves cured under these conditions are considerably lighter in weight than those cured after being separated from the stalk. The most careful experiments on this point have shown that picked leaves are about 11 per cent heavier after curing than those cured on the stalk. It has also been found that when suckers are left on the stalk at the time of harvesting there is a still greater loss

in weight by curing the entire plant. We have very little accurate information as to the relative effects of the two methods of curing on the quality of the leaf, but, other things being equal, it is probable that the picked leaves will have more of the so-called "gum" and more body than those cured on the stalk.

In the case of the yellow tobacco, the curing on the stalk is modified in that the stalk is split open for almost its entire length. This class of tobacco, furthermore, is all cured by artificial heat, and both of these circumstances, of course, operate to greatly shorten the life of the stalk after it is placed in the barn. Hence there is little opportunity for the transportation of material from the leaf into the stalk. But here again curing on the stalk serves to keep the leaves living for a longer period than is the case when they are picked. This class of tobacco is very rich in starchy matters, and while these may not be transported into the stalk they would be more completely consumed by the leaves themselves when cured on the stalk. This naturally gives a tougher leaf, possessing relatively more gummy or resinous matter. At any rate, it is commonly believed by growers in the older yellow-tobacco districts that the best plug wrappers can only be obtained by curing the leaf on the stalk. Nevertheless, a good grade of wrapper is obtained in the newer districts of the yellow-tobacco belt by picking the leaves for curing.

THE AIR-CURING PROCESS.

Apart from the two different methods of harvesting and hanging the tobacco in the barn, the method of conducting the curing process is variously modified according to the uses for which the leaf is intended. These differences in procedure pertain chiefly to the rate of drying out of the leaf, and this in turn is controlled mainly by the use of artificial heat. The character of the cured product is greatly modified by these different methods of procedure, and it is necessary to consider separately the types cured with and those cured without the aid of artificial heat. In the latter case the process is known as air-curing and a large proportion of our finest tobaccos is cured by this method.

Practically all of the cigar tobaccos wherever produced and the immense quantities of Burley tobacco grown in Kentucky and adjoining States are cured without the use of artificial heat except during a siege of very wet weather. The tobacco is placed in the barn in the green state, usually after having been wilted, and the subsequent curing is controlled simply by opening or closing the ventilators as occasion demands. In considering the changes taking place in the leaf during the curing process, this may be divided into

two periods, during the first of which the leaf remains alive, while in the second the changes which occur have no connection with its life activities.

FIRST STAGE OF AIR-CURING.

The changes which occur during the first period of the curing, and which are by far the most important, are dependent upon the life activities of the minute cells which make up the body of the leaf. If a ripe tobacco leaf is killed outright with chloroform or with heat and then placed under normal curing conditions, it does not develop the characteristic properties of a well-cured leaf. It is certain, therefore, that in order to secure a satisfactory cure the conditions must be such that the leaf will remain alive long enough to allow these necessary changes to take place. In the curing shed the leaf undergoes a slow process of starvation unless it is killed prematurely by injury, such as bruising, by heat, or by too rapid drying out. Of course, the leaf must have food in order to remain alive, and this comes from the reserve supply which has been stored up.

We have seen that the ripe leaf is very rich in starch and that one of the important changes in the curing is the disappearance of this starch, which is consumed by the living portion of the leaf itself. Now, if the leaf is killed by bruising, rapid drying, or heating too high there is no means of removing this starch, and the tobacco is harsh, lifeless, and "strawy." The vitality of the tobacco plant is remarkable, and parts of the leaf will continue to live for several weeks in the curing barn under favorable conditions. After the starch is all used up it is probable that some of the nitrogenous constituents are attacked as a last means of prolonging the life of the residual living matter.

Along with these changes in composition the green color is replaced by a lemon-yellow. This change from green to yellow takes place in all tobacco, whatever the method of curing may be, if it is properly conducted. The green coloring matter of the tobacco leaf, called chlorophyll, is found in all green plants in very similar, but not identical, forms. During the period in which the leaf tissue is undergoing starvation, this green coloring matter is more or less completely changed into colorless substances, and the appearance of the yellow color marks the approaching death of the leaf. If the green leaf is killed outright soon after harvesting by bruising or rapid drying out, the green color can not be removed by any subsequent treatment the leaf may receive; but if the leaf remains alive for two or three days, even though the green color has not fully disappeared, that which remains may be removed by sweating or fermentation.

It must not be thought that the yellow coloring matter is formed during the curing process directly from the green coloring material. This yellow coloring matter is contained in the green leaf before it is harvested and also after it has turned brown. The yellow is simply obscured in these cases by the more intense green or brown. In fact, the yellow becomes apparent in the overripe plants in the field, and when the brown coloring matters are deficient it may still be visible after the leaf has been fermented. It is interesting to note that the green color is never entirely destroyed in the inner parts of the leaf, even after fermentation followed by a long period of aging.

SECOND STAGE OF AIR-CURING.

The full development of the yellow color marks the end of the first period of the curing. In the second period the changes which take place are not dependent on life processes, and hence can be accomplished in the fermentation bulk as well as in the curing barn. The fermentation is, in fact, merely a continuation of the second stage of the curing. The changes taking place in this case are for the most part quite different from those occurring in the first stage of the cure. After the leaf is dead, no more of the starch is consumed, nor are the protein nitrogenous compounds attacked. The changes consist mainly in the further breaking up of the products formed in the first stage of the curing. One of the most important changes is the development of the brown color. Here again it must be understood that the brown coloring matters are not derived from the yellow, nor are they derived directly from the green coloring material. They are formed by a process of oxidation which does not take place till the cells of the leaf are dead. As soon, therefore, as portions of the leaf die they at once begin to turn brown, provided sufficient moisture is present. The two essentials for the development of the brown color are a supply of oxygen, which is obtained from the air, and a sufficient amount of moisture. This development of the brown color, which is begun in the second stage of curing, is always completed in the fermentation of the tobacco, and the chief danger as regards the curing is that the development will proceed too far because of excessive moisture, causing the leaf to cure too dark. The amount of coloring matters in the leaf probably depends chiefly on the conditions as to soil, fertilizers, and climate under which the plant is grown, and so is not under the control of the operator in the curing. But the depth of the brown color is governed by the extent to which the oxidation is allowed to proceed, and this factor can be controlled by regulating the moisture supply.

It has been explained how the important changes in the first stage of the cure can only be effected by keeping the leaf alive for a sufficient period of time and that once the leaf has been killed these

changes can not be accomplished by any subsequent treatment. On the other hand, those changes occurring in the second stage of the curing take place after the leaf is dead and are largely continued in the subsequent fermentation. The extent of these changes is governed by the external conditions of temperature, moisture, light, and air supply. It is quite impossible to control these conditions properly in the curing shed, whereas they can be readily managed in the sweat room. It is therefore desirable to complete the second stage of the cure as rapidly as practicable and then to keep the tobacco comparatively dry until it is ready for fermentation. A great deal of air-cured tobacco, especially of the cigar types, is seriously injured in quality every year because of the damp or cold weather encountered during the last stage of the curing and in the interim before the tobacco is removed from the barn. These unfavorable weather conditions greatly prolong the final drying out of the leaf and cause a sort of cold sweat to take place, which prevents a normal sweat in the packhouse. It is a common experience among packers to find that tobacco cured under these conditions will not heat up properly in the bulk.

As regards quantity, the most important change in the curing is the loss of water. The tobacco leaf normally loses about 75 per cent of its green weight in the curing, and by far the greater portion of this loss is water. Thus it has been found that 8,000 plants grown on an acre of ground in the Connecticut Valley and yielding about 1,800 pounds of cured leaf weigh when harvested something like 8 tons, of which fully 6 tons are water. To cure tobacco successfully this vast amount of water must be removed under such conditions and at such rate as will best allow the other important changes to take place.

THE MOST FAVORABLE CONDITIONS FOR AIR-CURING.

The question now arises as to the most favorable conditions for air-curing and the means of controlling these conditions. It has been shown that the principal changes taking place in the first stage of curing are due directly to the activities of the living cells while they are passing through a period of gradual starvation; hence, the conditions should be such as are most favorable to these activities. These cells are killed by bruising, so that it is important to avoid injury in this way in the harvesting as far as possible. Again, these cells are killed by excessively low or high temperatures and by the rapid loss of water. The life activities of the tobacco plant practically cease at temperatures below 40° F., while they increase as the temperature rises, until at about 125° F. the living cells are rapidly killed. These activities are also greatly lessened by loss of water and cease as soon as the leaf becomes dry. In practice, the most favorable temperatures for curing lie between the limits of 60° and 100° F., and the relative

humidity should be about 85 per cent. Under these conditions the leaf will gradually lose its water, but will never be out of case or order and the curing will proceed smoothly. If the humidity becomes much higher, pole-sweat will develop on the leaves most advanced in the curing, while if the humidity falls much below this figure the leaf will dry out too rapidly.

In the second stage of the curing, when the leaf begins to turn brown, there is no longer any need for keeping the air in the barn so moist, and the relative humidity may be lowered to about 80 per cent, and later still further reduced to 65 or 70 per cent, until the stems are dry. It is desirable to prevent the tobacco from coming into high case after curing until it is to be taken down, and it should be stripped and packed as soon as possible after the curing is completed. So long as artificial heat is not used the temperature will never become too high for favorable curing, but it frequently becomes so low as to seriously interfere with the process.

Unfortunately the growers at the present time have very limited means of controlling the temperature and relative humidity in the barn in the air-curing process. It is indeed a remarkable fact that the methods employed in this process are the crudest of all those used in curing tobacco, for the operator is almost at the mercy of the weather conditions. If the season is too dry, the tobacco "hays down"—that is, simply dries out like hay—while if it is too wet, the tobacco is seriously damaged by pole-sweat. Of course marked advances have been made in this method of curing in recent years, but these improvements consist chiefly in the construction of better barns, which is only one step in the right direction. It remains for some one to work out a practical method of controlling the temperature and humidity in the barn when the weather conditions are unfavorable. Many thousands of dollars' damage to the tobacco crop results annually from lack of means for maintaining the proper conditions in the barn during the curing period, and this loss can never be overcome until satisfactory means are provided for conducting the cure independently of outside weather conditions.

All experienced tobacco growers are aware of the serious damage likely to result from pole-sweat during the periods of very wet weather, but few of them appear to fully appreciate the extent of the injury in quality caused by the opposite extreme of excessively dry weather. This fact is probably due to the circumstance that injury by pole-sweat is of such a character that it is promptly recognized, since the tissues of the leaf are actually disintegrated, while, on the other hand, tobacco which has been dried out too rapidly is perfectly sound, and its inferior quality is not fully apparent until after it has been fermented, when it is likely to be attributed to other

causes. Although in this case the value of the leaf is never entirely destroyed, the damage is more widespread and of more frequent occurrence, so that in the aggregate it probably amounts to more than that caused by pole-sweat. The average grower, in his anxiety to avoid pole-sweat, is apt to hasten the first stage of the cure far too rapidly to secure the best results.

POLE-SWEAT, OR HOUSE-BURN.

This disease, which is especially to be dreaded during periods of prolonged wet weather accompanied by relatively high temperatures, occurs the world over where tobacco is cured without the use of heat. It is caused by some of the lower organisms which attack those constituents of the leaf which give it toughness and stiffness. As a result, the tissues soften and lose their coherency, so that the leaf simply falls apart. These organisms are not true parasites—that is, they do not attack living matter—so that pole-sweat can not occur until after the leaf tissue dies. But of course some parts of the leaf may die much sooner than others, so that pole-sweat may appear before the entire leaf is dead. Naturally, it first attacks those leaves which have been bruised or broken in harvesting. Again, it appears first on the lower leaves of the plant, which die more rapidly than the upper, greener leaves. Its development is greatly favored by crowding the plants or the leaves too closely, thus preventing the necessary ventilation.

The organisms which cause this trouble are not active at very low temperatures, so that pole-burn does not appear to any extent in cold weather. Furthermore, they only thrive in the presence of an abundance of moisture. The three essential conditions for the rapid spread of the disease, then, are: (1) Tobacco which has passed through the first stage of the cure or which has been killed by bruising or other injury; (2) a temperature ranging from 60° to 100° F.; and (3) a relative humidity of 90 per cent or more, which checks the evaporation from the leaves, causing them to become soggy. Under these conditions it is amazing to note the rapidity with which the trouble spreads throughout the barn. Of course, conditions favorable to pole-sweat may exist for short periods without the appearance of the disease, but it will certainly develop if these conditions continue from twenty-four to forty-eight hours.

True pole-sweat implies more or less decay of leaf tissue, but the leaf may be discolored without materially affecting its soundness. This is caused by short periods of excessive humidity which do not continue long enough for the development of the organisms which attack the leaf structure. In this case dark-colored oily drops collect

on the surface of the leaf, especially at the tips, and when these evaporate dark spots are left. Such spotted leaves are almost worthless for bright wrappers, although the tissue is perfectly sound.

There is no doubt that the remedy for this disease lies in controlling the humidity in the curing barn during periods of excessively damp weather, but so far no cheap practical method of accomplishing this has been devised. It is believed by some growers that ventilation affords protection, but if the relative humidity outside of the barn is above 90 per cent, ventilation alone can not possibly do any good. The whole problem lies in keeping down the humidity, and the only practical method of doing this consists in the combined use of heat and ventilation. Various means of introducing heat into the barns during unfavorable weather conditions have been tried, and some of these have been successful under certain conditions. We have seen that either excessive dryness or excessive moisture in the barn during the curing process will seriously injure the value of the tobacco. Where the color of the product is of importance, injury will result from excessive humidity whether or not pole-sweat appears. The control of this disease is therefore merely one phase of the more general problem of maintaining in the barn the most favorable conditions for the development of the finest qualities in the leaf.

AIR-CURING AS AFFECTED BY HEAT AND VENTILATION.

One of the pressing needs at the present time in the production of air-cured tobacco is some adequate means of controlling the temperature and humidity in the curing barn whereby the process can be conducted more or less independently of the outside weather conditions. With the hope of stimulating interest in this problem among growers, some of the fundamental principles which must be made use of in any practical solution are briefly stated in the following paragraphs.

Tobacco as it is hung in the barn contains an enormous amount of water which must be removed by evaporation from the surface of the leaves and at such rate as will allow certain important changes in composition to take place. So long as the minute cells of the leaf remain alive they resist the loss of water, so that it is only given up slowly unless the surrounding air is quite dry. On the other hand, as soon as the cells are dead, marking the end of the first stage in the curing, the remaining water is set free and will ooze out to the surface of the leaf whether or not the surrounding air be dry.

Accordingly, the first stage of the cure can be prolonged as far as is necessary by keeping the surrounding air moist, while in the second stage the water must be removed as fast as it comes to the surface of the leaf by keeping the air sufficiently dry if we are to avoid injury from pole-sweat or discoloration. At the time the tobacco is

hung in the barn, water is evaporating from the surface of the leaves, and this evaporation continues until the surrounding air is saturated with moisture. A given volume of air, or, more correctly, the space containing this air, is capable of taking up a certain amount of moisture and no more at any particular temperature. Hence, the evaporation from the fresh tobacco leaves will soon cease unless the surrounding air which has become saturated is replaced by a fresh supply of drier air. In other words, we must have ventilation.

Contrary to the general impression, moist air is lighter than dry air at the same temperature, and consequently the saturated air in the barn will tend to rise to the top, while the heavier, drier air will flow in from the outside to replace it. Again, warm air is lighter than cold air and will rise, so that when the sun shines on the roof of the barn, thus warming up the upper sections of the inclosed air, this warmed air is forced upward by the cooler, heavier air near the ground. For these reasons the natural course of ventilation in the curing barn is for the cooler, drier air to enter the barn near the bottom, pass upward through the tobacco, thus absorbing more moisture and becoming warmer, thereby growing constantly lighter, and finally to pass out of the top of the barn. Of course, if the wind be blowing briskly the air may be driven directly through the barn when ventilators are opened on the sides, thus providing a sort of forced ventilation.

In moderately dry weather it will be seen that ventilation is all that is needed to secure favorable curing conditions, provided the temperature is not too low, but that ventilators should be provided at the top of the barn as well as on the sides. In very dry weather the evaporation from the leaves should be kept in check by having the barn built as tight as possible and by keeping all ventilators closed during the day. In this case it is well to open up the ventilators during the night in order to insure plenty of fresh air in the barn. Unfortunately this precaution against injury from dry weather can not be satisfactorily observed under present conditions, owing to the danger of pole-burn which would be incurred in case a prolonged season of wet weather should follow. Yet there is no doubt that many growers allow their tobacco to dry out too rapidly by opening all ventilators on dry days.

While the rate of curing can be satisfactorily controlled when the weather conditions are just right or when it is too dry by proper management of the ventilation, it is quite different in either cold or very wet weather. If the temperature is low, the curing changes are stopped, although the tobacco may continue to dry out. In this case the leaf is simply dried and not cured. During rainy or foggy weather the air is practically saturated with moisture, and since it

can not take up any more it is obvious that ventilation alone is useless under these circumstances. Now, the capacity of the air for water vapor is greatly influenced by the temperature; thus, at 52° F. a cubic foot of saturated air contains 0.00063 pound of water vapor, while at 72° F. the capacity is increased to 0.00122 pound. By raising the temperature of the air 20 degrees we double its capacity for holding moisture. It is obvious, therefore, that if air which is saturated with moisture enters the barn and if its temperature is raised 20 degrees the relative humidity drops from 100 per cent to 50 per cent, or the air becomes about as dry as on an average bright, sunshiny day. Given some suitable means of maintaining the temperature in the barn from 15 to 20 degrees higher than that of the outside air, combined with proper ventilation, the problem of controlling the curing conditions would be solved.

If the air becomes saturated at any given temperature, any lowering of this temperature will cause some of the moisture to be deposited in the form of liquid. This is why pole-sweat progresses so rapidly when moderate temperatures are followed suddenly by warm, wet weather, for the warm, saturated air from the outside coming in contact with the cooler tobacco is chilled and actually deposits moisture on the leaf. For the same reason an insufficient quantity of heat is worse than none, for the temporarily warmed air absorbs more moisture from the tobacco in the lower part of the barn, but is cooled before it reaches the top and deposits this moisture on the tobacco in the upper part of the barn. Consequently, enough heat must be supplied to warm the barn up to the top and thus drive out the moist air.

AVAILABLE METHODS OF APPLYING ARTIFICIAL HEAT.

One of the first essentials is that the heat be produced at the bottom of the barn and properly distributed so that in rising it will be forced to pass through all portions of the tobacco. Otherwise local currents will be set up, while a large portion of the air remains stagnant. Herein lies the great objection to the open fires which are sometimes resorted to. It is impossible to avoid overheating the tobacco hanging directly over the fires, while that between the fires does not receive enough heat. Obviously the greater the number of fires the more satisfactory will the result be. This method of applying heat has been successfully used in sections where the leaves are picked from the stalk before curing, but when the leaves are cured on the stalk it has not been found satisfactory. In addition to the uneven distribution of the heat and the difficulty of maintaining anything like a uniform temperature a considerable amount of space in the barn must be sacrificed, for in hanging the tobacco at least a part of the lower tier must be left vacant. At best it is only a means of warding off

pole-sweat and does not reach the broader problem of maintaining the proper curing conditions in the barn at all times.

Steam as a source of heat presents many obvious advantages. This is apparently the only means of heating whereby the temperature can be distributed uniformly and readily controlled. Of course the first cost of installing a steam-heating system would be considerable, but it would last indefinitely. With a system of this kind the curing could be carried out independently of the weather conditions. In considering the cost and value of any system of heating it should be remembered that protection against pole-sweat is by no means the only object to be sought. It rarely happens that the most favorable conditions of temperature and humidity prevail during the curing season, and there can be no doubt that the value of the crop would be materially increased by the judicious use of a steam-heating system. The practical question is whether the increase in the quality of the leaf would be sufficient to warrant the use of this system.

Recent experiments with a system of flues for supplying heat similar to those employed in curing yellow tobacco have given promising results. Here, again, the principal difficulty to be overcome lies in the proper distribution of the heat. The barns used in the flue-curing districts are not more than 24 feet square, so that the flues are never more than 6 or 8 feet apart. It will be seen that a large number of flues, with a corresponding number of furnaces, would be required for the barns in the air-curing districts. It would scarcely be practicable to set these flues up in permanent form, so that it would be necessary to take them down before putting in the tobacco and before taking it down again after curing. It is not a difficult matter, however, to set up the flues, and they may prove to be the practicable mean between the ideal but costly steam-heating system on the one hand and the unsatisfactory method of using open fires on the other.

MODIFICATIONS OF THE AIR-CURING PROCESS.

The air-curing has been discussed mainly from the standpoint of cigar tobaccos, but the same principles apply to other types, more particularly the Burley tobaccos. The changes which take place in the first stage of the cure are of the same character, but the final color changes are somewhat different. Instead of the characteristic brown of the cigar leaf the Burley should have a golden red color after curing. In each case, however, the brightest colored leaf commands the highest price, so that Burley tobacco, like the cigar leaf, should not be exposed to excessive moisture in the last stages of the cure.

In a few counties of Virginia a type of plug tobacco is produced which is known as "sun-cured tobacco." The tobacco is hung on scaffolds, exposed to the sun for several days, and then transferred to the

barn, where the curing is completed without the use of artificial heat. This method of curing has not been investigated, and practically nothing is known of the differences in composition between sun-cured and ordinary air-cured tobaccos.

THE FLUE-CURING PROCESS.

The distinctive feature of the flue method of curing is that the barn is provided with a system of large pipes through which the heated air is passed throughout the curing period. The smoke does not come into contact with the tobacco and the cure is completed within a few days. One of the principal factors controlling the value of the leaf cured by this method is the color, and the two prime conditions for success in this respect are the right kind of soil and the proper control of the curing. The color most desired is a characteristic bright lemon-yellow, and, in addition, the leaf should have sufficient gummy matter to give it flexibility, but it must also be of a spongy character, so that it will absorb large quantities of the sauces used in manufacturing chewing tobacco.

CHANGES IN THE COMPOSITION AND PROPERTIES OF THE LEAF.

In the flue-curing method, just as in the air-curing process, the principal changes in composition brought about in the curing are dependent on the life activities of the minute cells in the leaf, and the nature of the changes in the two methods is the same. The main difference lies in the extent or completeness of these changes. The typical bright yellow tobacco at the time of harvesting is riper than most tobaccos cured without the use of heat. Partly on this account, and also because of the character of the soil on which it is grown, this type of leaf is relatively richer in starchy matter and poorer in organic nitrogenous materials, particularly the coloring matters.

Because of the difference in composition, combined with the effects of higher temperatures and more rapid drying, the green color is removed much more rapidly. It is to be remembered that here, as in all other types of tobacco, the yellow color is not formed directly from the green, but is already present in the green leaf. The rapid appearance of the yellow color does not afford sufficient time for the transformation of all the starchy matter, and as soon as this stage is reached the drying must be hastened so as to prevent any further change in color. Evidently, then, the flue-curing method consists essentially in the hastening and shortening of the first stage in the air-curing process, while the second stage of the cure, made apparent by the development of the brown color in the case of cigar tobaccos, is not allowed to take place at all.

CONDITIONS AFFECTING THE RATE OF CURE.

It is interesting to note the large number of formulas or rules which are in use in curing this type of tobacco, any of which will give satisfactory results in certain cases. This is due partly to differences in the tobacco when harvested and partly to the fact that all of these formulas are based simply on the temperature in the barn, with scarcely any reference to the humidity, which is really the controlling factor in the rate of curing. The principal function of the artificial heat is to regulate the humidity, and obviously this is also dependent on the amount of water in the tobacco and on the prevailing weather conditions.

The capacity of the air for holding moisture, and consequently its drying capacity, depends principally on its temperature, and air which is already saturated has no drying power until its temperature is raised. Satisfactory curing can only be accomplished by proper regulation of the rate of drying, and this depends chiefly on the humidity of the air in the barn. From these facts it is clear that in order to maintain a definite rate of drying by controlling the humidity, the temperature in the barn must bear a certain relation to that of the outside air, and the difference in temperature inside and outside the barn will be influenced by the humidity of the outside air. In warm weather the temperature inside the barn must be higher than in cool weather, and in rainy or in foggy seasons it must be higher than in clear, dry weather.

In addition to temperature there is another equally important factor in controlling the humidity in the barn, and consequently the rate of drying, and this is ventilation. If the barn were perfectly tight, the air within would of course soon become saturated, and the inevitable result would be that the tobacco would sweat; that is, drops of water would collect on the surface of the leaves. The warm saturated air in the barn must therefore be constantly replaced by the cooler, less humid outside air, and hence proper means of ventilation should be provided. It is astonishing to note the small number of growers who fully appreciate the importance of ventilation. Most barns are built without any provision for ventilation, and the only reason that curing can be successfully done in these cases is that the barns are not sufficiently tight to prevent the natural ventilation caused by the higher temperatures within. Frequently this natural ventilation is insufficient, and at the critical moment the tobacco is irreparably damaged by discoloration because of lack of means of ventilating the barn to remove the excessive moisture. On the other hand, there are times when it is desirable to check the rate of drying, so that it is important to provide ventilators at the top and bottom of the barn which can readily be closed when occasion demands.

MANAGEMENT OF FLUE-CURING.

The completion of the curing proper is marked by the development of the yellow color. This transformation from a green to a yellow color, along with other attendant changes, takes place while the leaf is still living, and if the leaf is quickly killed by heat or by being rapidly dried it will be impossible to remove the green color. At temperatures above 125° F. the leaf is rapidly killed, so that this limit must not be exceeded during the yellowing process. The greatest danger in this first stage of the curing, however, is that the leaf will dry out so rapidly as to prematurely kill it. After the leaf is dry no amount of heat can remove the green color. The yellowing process may be accomplished at any temperature ranging between 80° and 120° F., provided the humidity in the barn be properly managed.

Care must be taken to avoid drying the leaf too rapidly during the first stage of the cure, but as it begins to yellow the humidity in the barn must be materially decreased by slowly raising the temperature and gradually increasing the ventilation. If these two points are carefully observed there will be little trouble from so-called "sponging" or "scalding." As soon as the leaf has become yellow the whole problem is to regulate the drying so as to prevent any further change in color. This second stage of the curing, known as "fixing the color," is the critical period and requires the closest attention. There are two fundamental facts of the greatest importance in this connection, namely, that the brown or red color can not appear until the leaf is killed and that it develops only in the presence of considerable moisture.

The appearance of the yellow color indicates that the leaf has reached the dying stage, but it still contains a large amount of water. When the leaf tissue dies all the moisture within the leaf is released and will rapidly move to the surface, so that unless this moisture is promptly removed the leaf will certainly begin to turn a reddish brown color. To avoid this injury to the tobacco the heat must be raised very slowly, so as to kill the leaf tissue gradually, and, more important still, plenty of ventilation must be provided to take away the moisture. The temperature should not be allowed to fall during this period.

In addition to this reddening of the leaf, commonly called "sponging," which is caused by failure to remove the moisture by sufficient ventilation, there is often trouble from a somewhat different discoloration, known as "scalding," or "splotching." The primary cause of this is advancing the temperature too rapidly while the leaf still contains much moisture. The rapid increase in temperature

kills the leaf cells so rapidly that the water which is set free brings to the surface of the leaf some of the coloring matters from within, and the result is a bluish black discoloration.

CURING TOBACCO WITH OPEN FIRES.

In the districts where heavy shipping tobacco is grown the so-called "fire-curing" is almost universally employed. This method is really a sort of combination of the air-curing and flue-curing processes, differing from the former in that artificial heat is invariably applied in the later stages and from the latter in that the heat is applied by means of small open fires. The first stage of the cure is identical with the ordinary air-curing, and the changes which take place are of the same character. After the tobacco has been curing for four or five days, either on scaffolds in the field or in the barn, small fires are started and only very moderate temperatures maintained for about twenty-four hours. After this the temperature may be considerably increased. When the leaf and half the stem are cured the fires are withdrawn and the tobacco allowed to soften up again, after which the fires are again started.

The tobacco in the fire-curing districts is characterized by an extremely thick, heavy leaf, very rich in nitrogenous matters, and hence it cures very slowly. Before the fires are started the greater portion of the starch has been used up, and this change is necessary to give the leaf the required flexibility. The low heat which is then applied is necessary to hasten the curing, particularly the removal of the green color, and to reduce the moisture in the leaf so as to prevent blistering or splotching when the temperature is advanced. The application of heat to this tobacco as soon as harvested would not afford sufficient time for the curing changes to develop before the leaf became dry. On the other hand, if the removal of the green color were not hastened by the use of artificial heat the time required for this change would be so long as to cause the appearance of the reddish brown color.

Tobacco cured by this process is exposed directly to the smoke from the open fires, and consequently acquires a characteristic flavor and odor. The substances of a creosotic nature absorbed from the smoke have marked antiseptic properties and prevent the leaf from suffering injury in shipment to foreign countries.

PART II.—PRACTICAL METHODS OF CURING AS APPLIED TO THE VARIOUS TYPES OF TOBACCO.

CIGAR TOBACCOS.

To a certain extent every tobacco plant produces the three components of the cigar, the upper leaves being used for the filler, while the lower ones furnish the binder and wrapper. In practice, however, the soil and climatic conditions of the different cigar-tobacco districts do not produce these three grades of leaf to the same degree of excellence, so that these districts are generally classified according to the particular grade of leaf they produce to the best advantage. Thus, the light, sandy soils of the Connecticut Valley produce a thin, fine-textured leaf especially adapted for wrappers but lacking in the flavor and aroma essential for filler purposes, whereas the heavy soils of Ohio produce a heavy leaf poorly suited for wrappers but prized as a filler because of its characteristic flavor and aroma.

The bulk of the cigar-tobacco crop at the present time is grown in the States of Massachusetts, Connecticut, New York, Pennsylvania, Wisconsin, Ohio, Florida, Georgia, and Texas. The finest grades of wrapper leaf are grown in a few counties of western Florida, southern Georgia, eastern Texas, and in the Connecticut Valley, while Wisconsin is known as a binder State and New York, Pennsylvania, and Ohio produce mainly filler grades. All cigar tobaccos are cured without the use of artificial heat, and the general methods of procedure are essentially the same in all the cigar-tobacco-growing States except in the case of the shade-grown types of Florida and Connecticut. The methods of harvesting and curing this type of leaf differ sufficiently from those commonly in use to warrant special consideration.

CONSTRUCTION OF THE BARN FOR CURING CIGAR TOBACCO.

Great advances have been made in recent years in the construction of barns for curing cigar tobacco, and many of those now in use are well adapted to this purpose. The main improvements have been in building the barns more nearly weatherproof and in providing more efficient means of ventilation. In some sections there has been a marked tendency to increase the size of the barns, so that

now it is not unusual to find them 300 feet or more in length. The chief consideration in this increase of size has been one of economy in construction, but it is undoubtedly true that the best barn is the cheapest in the end, so that the deciding question should be whether the larger barn is better adapted to controlling the curing conditions. So long as the grower is dependent on outside weather conditions in curing his tobacco the danger from pole-sweat will be greater in the larger barn, because of the increased difficulty in maintaining the necessary ventilation, so that any gain in economy of construction is likely to be more than offset by this danger.

In building a good barn the two principal considerations to be kept in mind are to construct it as nearly air-tight as possible and at the same time to provide an efficient system of ventilation, for in the absence of any method of supplying artificial heat these constitute the only means of controlling curing conditions. A site should be chosen for the barn which is thoroughly drained and sufficiently removed from other buildings to allow free access of air. It should be as near the tobacco field as possible, for convenience in harvesting. A convenient width for the barn is 32 feet, while the length should be some multiple of 16 feet if the tier poles, which are 16 feet long, are to run lengthwise of the building. Many barns are built 4 tiers high, but the curing can be better controlled when the building is only 3 tiers high to the plate. The tobacco should not hang within 3 feet of the ground, so that the first tier of poles should be at least 8 feet from the ground and the remaining tiers 5 feet apart. Thus, a barn 3 tiers high will be 18 feet to the plate, or one 4 tiers high will be 23 feet to the plate. The sills for the frame should be raised at least a foot above the ground, resting on brick or stone piers. The roof is given a steep pitch and generally carries two additional tiers for hanging tobacco, the lower being composed of 4 rows and the upper of 2 rows.

The posts, plates, and beams used for the frame should not be less than 7 by 7 inches. At intervals of 16 feet posts, frames, and girders are set up across the barn the same as at the ends, thus dividing the frame into 16-foot sections, known as "bents." The importance of building the frame of stout, substantial timbers can be appreciated when it is remembered that each bent of the dimensions stated above is capable of holding 4,500 plants, which in the green state will weigh at least 20,000 pounds. The girders on the ends and on the bents for carrying the lower tier of poles should be made removable, while those for the two upper tiers should be well braced. The tier poles on which the tobacco is hung are 16 feet long and may be sawed out, though round poles serve just as well. They must be stout enough to carry 800 pounds.

The boards for the sides and ends should be of first-class quality, lined, and of uniform width. All cracks should be battened with thin strips about 3 inches wide, so as to make the structure as nearly weatherproof as possible. At least every third board should be hung on hinges as a ventilator. The boards may be put on either vertically or horizontally, and there are numerous ways of arranging the ventilators. If the boards are put on horizontally those used for ventilators are hinged from the upper edge and are generally tied together by vertical strips, so that all of them may be operated from the ground. When the siding is put on vertically those boards used for ventilators may be hinged either from the top or side, and in the former case are also usually tied together. In any case the ventilators

FIG. 1.—Type of barn used in northern cigar-tobacco districts, showing the arrangement of horizontal ventilators.

on the sides should extend nearly up to the eaves and those on the ends should be extended to the roof. There are some desirable features in all of these methods of ventilating, but the vertical system of ventilators hinged at the top is more in accord with scientific principles and possesses a number of advantages over the others. These ventilators furnish better protection from the direct sunlight and from the wind, while they always afford the largest opening for admission of air near the bottom, which is desirable since natural circulation is always upward. Extending along the entire length of the sides, a horizontal ventilator should be provided at the bottom for admitting air below the sills. Comparatively few barns at the

present time have any provision for ventilation on the roof, but any method of controlling pole-sweat in wet weather by the use of artificial heat will require some means of providing for the escape of the moisture-laden air at the top of the barn.

A barn 32 feet wide should have two driveways extending all the way through the building, and doors should be provided at each end of sufficient size to allow a team to be driven in or out without difficulty. Some barns have a greater width, thus affording room for three driveways. Again, in some cases, doors are provided on the sides opening into each bent, but this arrangement is not recommended, for it greatly increases the difficulty of rendering the structure weatherproof. The construction of barns used for curing cigar leaf in the southern districts is essentially the same as that of the barns in northern districts, except that the ventilators usually consist of windows at intervals of about 8 feet, $2\frac{1}{2}$ to 3 feet wide and 10

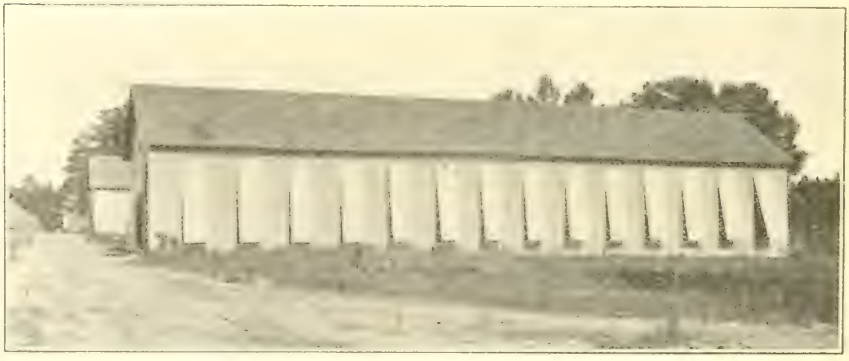


FIG. 2.—Type of barn used in southern cigar-tobacco districts, showing the arrangement of ventilators.

feet long, suspended at or near the top. A good type of barn fitted with a system of horizontal ventilators, which is used in northern districts, is shown in figure 1, while figure 2 shows the typical barn in use in the southern districts.

HARVESTING CIGAR TOBACCO.

In two or three weeks after topping, the plants will begin to ripen, as indicated by a change in color of the leaf. Light yellowish green flecks appear on the surface of the leaf and it snaps readily when folded back. To know just when the plants are ready for harvesting requires experience and good judgment, and much of the success in curing will depend on this point. Of course, all the plants do not ripen at exactly the same time, but usually in harvesting no attempt is made to single out the riper ones unless these occur in well-defined areas in the field. Cutting cigar tobacco in the northern districts usu-

ally begins about the middle of August and extends through the month of September, but the time may vary as much as three weeks in different years, depending on the season.

The stalks are cut with a variety of implements, among which are stout knives with hooked blades, an ordinary hatchet, a handsaw, or shears with long handles. The hatchet and shears are more commonly used, and the latter are becoming quite popular. The handles are of such length that the largest stalks can be cut easily and very rapidly. The plants are allowed to fall over in such a way as to leave all the butts one way in the row and facing those of an adjoining row. This greatly simplifies the subsequent handling of the plants, which are allowed to lie on the ground until wilted to such an extent that they can be handled without much breaking of the leaves. It is customary to wait until the dew is nearly off the ground before beginning to cut the plants in the morning, and care should be taken not to cut more during the day than can be handled before night. Tobacco may be seriously damaged by lying on the ground overnight, especially in case of rain. Due care must be taken also not to allow the leaves to become sunburned or blistered during the hottest part of the day. For this reason some prefer to cut the tobacco on a cloudy day.

The old method of stringing the plants on poles in the barn with twine has now been almost entirely abandoned, so that nearly all tobacco is cured on laths. By the old way the loose plants were hauled into the shed to be strung on the poles, while by the new method they are placed on the lath in the field. These laths are about twice the thickness of ordinary plastering laths, 4 feet in length, and generally carry 6 plants. The plants are attached to the lath in one of two ways. In the first case, a sharp-pointed spearhead is slipped over the end of the lath, by means of which the tobacco stalks are pierced through from 4 to 6 inches from the end and slipped on to the lath, the latter being held in a hurdle for this purpose, as shown in figure 3. In the second case, hooks are attached to either side of the lath, on which the plants are hung. On one side the first hook is placed 6 inches from the end, and on the other side a second one is fastened on 13 inches from the end, and so on, the lath thus carrying 6 hooks alternately arranged on either side about 7 inches apart. The plants can be hooked on in this way very rapidly and without being damaged, with the additional advantage that they are very accurately spaced on the laths.

Formerly it was the general practice to hang the laths bearing the plants on scaffolds in the field for several days before placing them in the barn for the final curing, but the more common way now is to haul the tobacco directly to the curing shed. The most convenient wagon rack for this purpose, which is very simple in construction, is

shown in figure 4. If the plants are speared on to the lath, this is carried to the wagon as soon as filled, but if the hooked lath is used the plants are carried to the wagon and hooked on to this after it has

FIG. 3.—Tobacco field, showing the method employed in spearing plants on a lath, with the hurdle used for supporting the latter during the operation.

been placed in position on the rack. The wagon rack for hauling to the barn referred to above is from 28 to 32 feet in length and will

FIG. 4.—The best form of wagon rack for hauling plants to the curing barn.

carry from 80 to 120 laths of tobacco. As soon as loaded the wagon is driven directly into the barn and the laths are hung on the tier poles, which are about 4 feet apart.

The matter of properly spacing the laths on the poles is one of the greatest importance. This depends largely on the size of the plants, but for an average crop the laths may be hung 6 inches apart on the top tiers and this space increased downward so that on the bottom tiers they lie 8 inches apart. The laths are accurately spaced on the poles by means of a small block of the proper length, which is carried in the hand. Tobacco hung close together cures better in a dry season, whereas damage from pole-sweat is correspondingly increased in a wet season, but as there is no means of knowing in advance whether dry or wet weather will be encountered the best that can be done is to follow a middle course. The upper tiers of the barn are filled first, the laths being passed up from the wagon by means of a fork with a long handle made for the purpose.

For several days before filling the barn with tobacco the doors and ventilators should be kept open to thoroughly air out the building, and as soon as the barn is full all loose leaves and trash should be removed from the floor. It is also a good practice to spread a coat of lime over the floor, the object being to prevent any undue fungous growth which might favor the development of disease in the curing.

CURING CIGAR TOBACCO.

The changes in the composition and properties of the leaf which take place in the curing process, as well as the most favorable conditions for accomplishing these changes, have been fully discussed in the first part of this bulletin. The great difficulty at the present time lies in the fact that we have such limited means of controlling the conditions of temperature and humidity in the barn that we are largely dependent on outside weather conditions for effecting the cure. Nevertheless, it is important to make the best possible use of such means as are available for bringing about the highest development of the important qualities in the leaf.

At the present time no artificial heat is used in curing cigar tobaccos save in case of danger from pole-sweat, when charcoal fires are sometimes resorted to. The only means of regulating the humidity in the barn, therefore, lies in the control of the ventilation, and the temperature depends solely on that of the outside air. There can be no doubt that eventually some practicable means of controlling the temperature and humidity by the use of artificial heat will be devised, but meantime more or less damage must necessarily result every year because of unfavorable weather during the curing season.

The fundamental principle to be kept in mind during the first stage of the curing is to avoid too rapid drying out of the leaf. It is certain that many growers, in their anxiety to avoid damage from pole-sweat, caused by excessive moisture, injure their tobacco very

seriously by going to the other extreme of drying out the leaf so rapidly as not to allow sufficient time for those changes to take place which are essential to good curing. As was explained in the first part of this bulletin, the essential changes taking place in the curing are dependent on the life activities of the leaf, and are therefore stopped as soon as this is killed by loss of water. Consequently, if the outside air is very dry the barn should be kept closed during the day and opened up at night. The object is to keep the moisture of the air in the barn quite high until the important changes in composition have taken place, as shown by the change in the color of the leaf from green to yellow. Warm temperatures also greatly favor these changes. Of course, if the outside air is quite humid the barn should be kept open during the day, and if it is moderately dry the ventilators should be opened only at the bottom.

As soon as the yellow color develops, the humidity in the barn should be reduced, for the development of the brown color which soon follows indicates that the leaf is beginning to die, and this is the critical stage in the cure. If the humidity remains very high at this stage for any considerable period, pole-sweat will surely develop. This is to be especially feared if a season of warm, foggy weather sets in, and may soon render the entire contents of the barn practically worthless. The only remedy lies in the use of artificial heat to keep down the humidity. Ventilation alone will be of little avail. The possible methods of supplying artificial heat have been discussed in the first part of this bulletin (see p. 20).

Entirely aside from the danger of pole-sweat, however, there are other important reasons why the humidity in the barn should be reduced as soon as the brown color begins to develop. The leaf dies at this stage and the true curing changes are stopped. All further changes in composition and properties are such as can be better controlled in the sweat room, where the ventilation, temperature, and humidity can be easily regulated, than in the curing shed. At the present time the demand is for bright colors in wrapper leaf, and the longer the second stage of the cure is protracted by a relatively high humidity the darker will the leaf be. Again, each time the tobacco comes into high case, after the cure is finished, the color will be further deepened. The rational method of procedure, therefore, is to maintain a high humidity during the first stage of the cure and then, as soon as the color has developed, to dry out the leaf comparatively rapidly. After the cure is finished, the tobacco should be prevented from coming into high case or order until it is to be taken down, so far as this is possible.

The time required for completing the cure varies from six or eight to twelve weeks, depending on the character of the season. As has

been already stated, quick curing may be depended on to give the best results, provided the first stage is not unduly hastened. The cure is finished when the midrib of the leaf has dried out so that it will snap when bent between the fingers. When the tobacco is ready to be taken down, the stalks are still quite green, and would remain so for many weeks longer.

STRIPPING AND ASSORTING CIGAR TOBACCO.

As soon as possible after the tobacco is cured, the plants should be taken from the laths and the leaves stripped from the stalks. This can not be done, however, until after damp weather has prevailed long enough for the leaf to become pliable, so that it can be handled readily without breaking. Tobacco in this condition is said to be "in case" or "in order" and weather well adapted to bringing it into case is frequently spoken of as a "tobacco storm." Tobacco will not come into order, however, if the temperature be very low, even when wet weather prevails. If the stalks have been frozen it is well to leave the plants hanging until the dripping stops, so as to avoid staining the leaf.

As the plants are taken from the laths, they are piled in heaps on a floor of poles or boards, the tips all being turned inward and overlapping to prevent the leaves from drying out. The leaves should be stripped from the stalks as soon as possible after the plants have been taken down, so as to avoid the heaps becoming heated. All of the top leaves are first stripped off and placed in a pile designated as "fillers"; then the next three or four are taken off and placed in a second pile called "seconds." Finally, the best leaves are classed as "wrappers," all damaged leaves being thrown out. These different grades are then tied into bundles, called "hands," using a leaf as a binder. The bundles should be made of leaves of uniform length and of the same quality, the whole weighing about one-half pound. Care must be taken to exclude from the best grade all leaves showing injury or discoloration. After the leaves have been tied into bundles these are arranged in bulks on an elevated platform. These bulks are built by laying the bundles in two rows with all the butts outward and the tips of the bundles in the two rows overlapping somewhat. The bulk is covered with oilcloth or other suitable material to prevent the leaves from drying out. They must be carefully watched to prevent their becoming heated, which is particularly liable to occur if the leaf is packed down too moist. If heating does occur, the piles must be torn down, and rebuilt after the bundles have been shaken out.

Before the leaf is ready for the manufacturer it must undergo a process of fermentation, commonly spoken of as "sweating." To

carry out this process successfully requires a thoroughly equipped plant with adequate facilities for controlling ventilation, temperature, and humidity, so that as a rule the growers sell their leaf in the bundle to the dealers who make a business of carrying on the fermentation on a large scale. The tobacco must also be very carefully assorted into grades, but the dealer generally prefers to do this himself in order to secure greater uniformity; and the grower, unless thoroughly experienced in the business, does well not to attempt the work of grading. This work of grading and fermenting cigar-leaf tobacco has become a highly specialized industry, quite distinct from the curing process, properly speaking, and so does not require further consideration here.

SHADE-GROWN CIGAR-WRAPPER LEAF.

In recent years the growing of Cuban and Sumatran types of cigar-wrapper leaf under artificial shade has become a very important industry in portions of southern Georgia and western Florida and in the Connecticut Valley. The details of harvesting and curing this leaf differ in some important points from those employed for the ordinary types grown in the open air, and therefore require some further consideration. The barns, however, are of the same construction as those used in curing the tobacco grown in the open air, except that, since the leaves are picked from the stalk in harvesting, the tier poles are only $2\frac{1}{2}$ feet apart vertically. The ordinary type of barn can therefore be very readily converted into one adapted to the shade-grown leaf by simply placing additional tiers of poles midway between the tiers already in position. A barn will hold about the same quantity of tobacco whether harvested on the stalk or by picking the leaves.

As has just been stated, all shade-grown leaf is picked from the stalk in harvesting, and this is done to insure the maximum yield of high-grade wrappers. Tobacco grown under shade does not show the ordinary signs of ripening so clearly as does that grown in the open air, and, moreover, to get the best results it is necessary to harvest the leaves before they would ordinarily be considered fully ripe. When ready for harvesting the lower three or four leaves are picked by hand and packed in baskets lined with burlap. The baskets, as soon as filled, are hauled to the curing shed, those exposed to the sun being covered with burlap to avoid injury to the leaves. A convenient rack for hauling the baskets to the barn is shown in figure 5. The field is gone over three or four times before all the leaves are harvested, the object being to pick all of them when at just the right stage of maturity.

In southern districts the leaves are strung on cords attached at each end to laths. These laths are of the same length but smaller than those used for curing tobacco on the stalk. A notch is made with a saw in each end of the lath and one end of the cord is drawn into one of these notches, wrapped around the end of the lath, and again drawn into the notch. The leaves, 30 or 40 in number, are then strung on the cord by means of a large steel needle and the free end of the cord is attached to the second end of the lath in the same manner as in the first case, care being taken to draw the cord sufficiently tight to prevent too much sagging. The leaves are strung on the cord in pairs, as it were, so that the front surfaces of each pair are face to face and the backs face the backs of adjoining pairs. This is done to prevent the leaves from sticking together as they curl up from loss of water.

FIG. 5.—A very convenient wagon rack for hauling baskets of picked leaves to the curing barn.

In the Connecticut Valley some growers string their tobacco on cords in the manner just described, but a second method of hanging the leaves is coming into extensive use. Small, slender wire nails are driven through each side of the lath at an upward angle and at intervals of 2 inches, beginning 4 inches from the ends. This provides 40 spikelets in all, 20 on each side, and on each of these one leaf is hung. The leaves are all hung so as to face outward. In this case the leaves hang with their flat surfaces parallel to the long axis of the lath, while those strung on cords hang with their surfaces at right angles to this axis. Each of these methods of stringing the leaves possesses points of advantage, and it is difficult to determine just which is the better one. The work of stringing the leaf is usually done by girls or boys, some of whom develop remarkable dexterity. The laths carrying the leaves are hung on the tier poles

at intervals of 4 to 6 inches, depending on the size of leaf. The method of arranging the laths on the poles in the barn is shown in figure 6.

MANAGEMENT OF THE CURING BARN.

The changes in composition of the leaf are doubtless of the same character as those which take place in curing tobacco on the stalk, but less complete than in the latter case. The two important differences in the two cases are that the picked leaves cure much more rapidly than those left on the stalk, and the conditions in the barn as to humidity and temperature are more easily controlled. Both of these

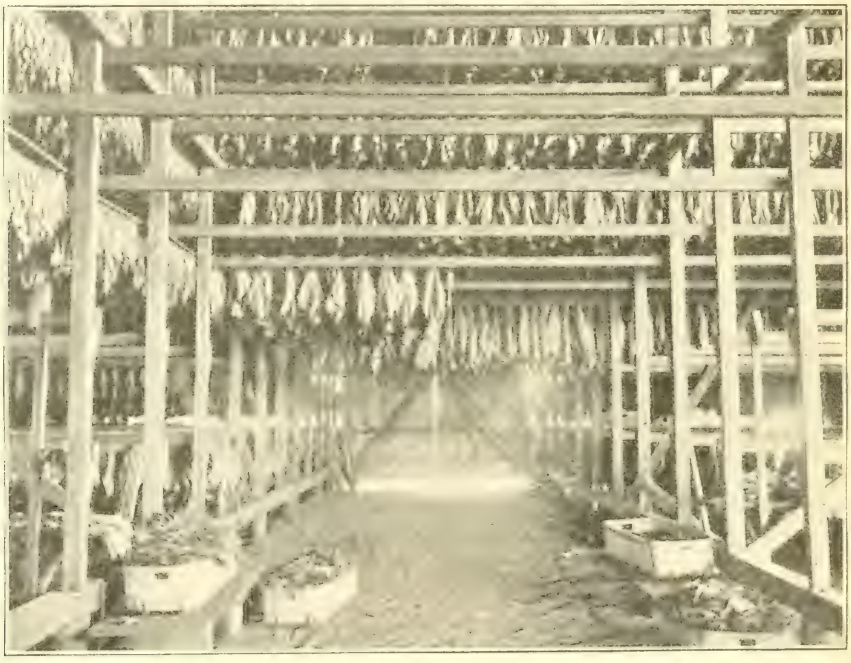


FIG. 6.—The interior of a cigar-tobacco barn, showing the arrangement of tier poles and the method of hanging picked leaves.

facts are due to the circumstance that the stalks, which contain so much water and give up this water so slowly, are not placed in the barn when the leaves are harvested by picking.

During the first stages of the curing due care must be taken to prevent the tobacco from drying out too rapidly. If the weather be very dry, the ventilators should be kept open for only a few hours in the morning. The picked leaves are whipped about by the wind more readily than those cured on the stalk, and hence the ventilators must be closely watched in windy weather to prevent injury to the tobacco from this source. As soon as the brown color develops,

the leaf may be allowed to dry out rather rapidly. The leaf proper cures down in a short while, but a much longer time is required for completely drying out the stems. The picked leaves are subject to pole-sweat at the critical stage, the same as when cured on the stalk, but of course the danger period is much shorter in the former case. Under favorable conditions the curing will be completed in from four to six weeks.

After the tobacco is completely cured it is allowed to hang in the shed until the weather becomes sufficiently moist to soften the leaf so that it can be handled without breaking, when it is taken down and tied into bundles. If the leaves are strung on cord, this is cut from the lath, the leaves slipped to its center, and tied with the free ends. In this case the entire contents of the barn may be taken down before the tobacco is removed from the laths, these being piled in bulks on a

FIG. 7.—Type of tobacco barn used in the Burley district of Kentucky.

temporary board floor. If the leaves are hung on the nail laths they must be stripped off from these as fast as they are taken down and tied into bundles in the same way as when cured on the stalk.

BURLEY TOBACCO.

Burley tobacco requires a fertile limestone soil for its highest development. The bulk of the crop is grown in the district embraced in the States of Kentucky and Ohio which borders on the Ohio River. Burley tobacco is also grown in considerable quantities in parts of Tennessee and West Virginia and in a small way in several adjoining States. Like cigar tobaccos, it is cured without the use of artificial heat except when there is danger of injury from house-burn, or pole-sweat. There are many types of barns in use for curing, ranging from the small crude log structure to the most approved modern

frame building with ample facilities for controlling the ventilation. These modern barns are essentially the same as those used in the cigar-tobacco districts, which have already been discussed, and so need not be further described here. An approved type of barn is shown in figure 7.

HARVESTING BURLEY TOBACCO.

When fully ripe the plants are harvested by first splitting the stalk with a knife down about two-thirds of its length, then cutting it off near the ground and placing it astride a stick. The sticks are 4 feet 4 inches long and carry five or six plants, depending on their size. These are loaded on a rack similar to that shown in figure 4, hauled to the barn, and hung on the tier poles at intervals of about 12 inches. Some growers prefer to hang the tobacco on scaffolds in the field for two or three days, so as to allow it to become thoroughly wilted before housing it. In this case it can be safely hung considerably closer together in the barn than when carried directly from the field to the barn.

CURING BURLEY TOBACCO.

The method of curing is the same as for cigar tobacco, and the changes which take place are of the same kind. When cured, however, the color is yellow to red instead of the characteristic brown of cigar leaf. If the weather is dry, the barn should be kept tightly closed during the day and open at night, while in wet weather thorough ventilation is required. If the weather is very damp during the curing period, the leaf cures down too dark. Some growers use small charcoal fires to dry out the barn when pole-sweat sets in. From five to eight weeks are usually required for completing the curing process.

ASSORTING AND PACKING BURLEY TOBACCO.

When taken down from the barn, the leaves are stripped from the stalk and assorted. The usual grades are (1) sand leaves, (2) trash, (3) lugs, (4) bright leaf, (5) red leaf, (6) tips. The three first-named grades are used principally for smoking tobaccos, the bright leaf for plug wrappers, and the red leaf and tips for plug fillers. These different grades are tied into bundles containing from 10 to 20 leaves and bulked down. The tobacco may then be packed at once into hogsheads or it may be allowed to remain in the bulk all through the winter, in which case it is hung up in the barn in the spring, where it undergoes a sort of sweat or fermentation. In either event it is packed under pressure into large hogsheads, which when filled hold from 1,000 to 1,500 pounds, and it is then ready for transportation to market.

SUN-CURED TOBACCO.

In a few counties of Virginia in the vicinity of Richmond a type of tobacco is produced which is much esteemed as a plug filler. This tobacco is cured by a modification of the air-curing process, which seems to develop its characteristic properties. After harvesting it is hung on a scaffold in the field, exposed to the sun until nearly cured, and then carried to the barn, where it hangs until ready for stripping. If the harvesting is followed by a period of cloudy weather, the tobacco, of course, receives little or no sunshine, and the curing approaches more nearly that of the cigar and Burley types.

YELLOW TOBACCO.

The yellow type of tobacco can be successfully grown only on light sandy soils which are, in general, poorly adapted to the production of most other crops. The importance of the character of the soil is well illustrated by the fact that small areas on a farm may produce a bright yellow leaf of the finest quality, while other portions of the same farm will grow only a heavy dark type, suitable for export. The bulk of the bright yellow tobacco is grown in North Carolina and in portions of Virginia, South Carolina, and Tennessee.

Equally as important as the character of the soil is the manipulation of the curing process. No other type of tobacco requires so much skill, experience, and good judgment for successful curing. Lack of attention even for a few hours during the curing may practically ruin the entire contents of a barn. The distinctive feature of the method used for curing this class of tobacco is the use of flues for conducting artificial heat into the barn in such a way that the smoke and gases from the fire do not come in contact with the leaf. The heating is kept up continuously from start to finish, thereby greatly shortening the curing period. Thus, except under unusually adverse conditions, the curing proceeds at a given rate practically independent of outside weather conditions.

CONSTRUCTION OF THE BARN FOR CURING YELLOW TOBACCO.

The type of barn most widely used in curing yellow tobacco is comparatively simple in construction and is characterized by its small size. These barns are generally, but not always, built square and vary from 16 to 24 feet in width, inside measurement. It is necessary that the inside width of the barn be some multiple of 4 feet, since this is the distance between the tier poles which extend across the barn lengthwise and receive the sticks on which the tobacco is hung. The first set of tier poles is placed 9 feet above the ground and each succeeding set 2 feet 8 inches to 3 feet higher. The smaller

sized barns are usually built 17 feet high to the eaves, and therefore contain four sets of tier poles, while the larger ones are frequently built 20 feet high and contain five sets of tier poles. Additional tiers may be placed in the roof.

The barns are generally built of logs, but many framed structures have been erected in some sections in recent years owing to the increasing scarcity of timber. When logs are used, the cracks are either chinked with mud or closed with lime mortar. A typical log barn is shown in figure 8. If framed barns are built, the cracks should be battened with thin strips of boards. Ventilation is usually secured by leaving openings around the bottom of the barn and by cutting small windows in the gable ends near the roof, which can be closed when desired. Many barns contain so many cracks and

FIG. 8. A typical log barn used in curing yellow tobacco, showing the ventilator in the gable and the outside portions of the heating system.

crevices, especially about the roof, that they require no special ventilators, but such barns are poorly adapted to curing yellow tobacco.

As explained in the first part of this bulletin, it is important to keep the barn tightly closed during the first stage of the curing, while in the second stage it is even more important to have ample ventilation. These requirements can only be met by building the barn as tight as practicable in the first instance and then providing a system of ventilators which can be opened and closed at will. Any reasonable outlay to secure these ends will be amply repaid, both in saving of fuel and in obtaining a finer quality of cured leaf.

The heating system consists of a series of sheet-iron flues leading from small furnaces placed at one end of the barn. The arrangement of the flues is comparatively simple, but is variously modified in different sections of the flue-curing belt. One of the best arrange-

ments for the larger sized barns is that shown in figure 9. The furnaces (fig. 9, F, F) are built of stone or brick and are usually about 18 inches wide and 20 inches high, inside measurement. The tops are arched and the walls are made sufficiently thick to avoid all danger of igniting the walls of the barn. The furnaces are built from 4 to 5 feet long, and project on the outside about one-fourth of their length. The flues are made in sections similar to ordinary

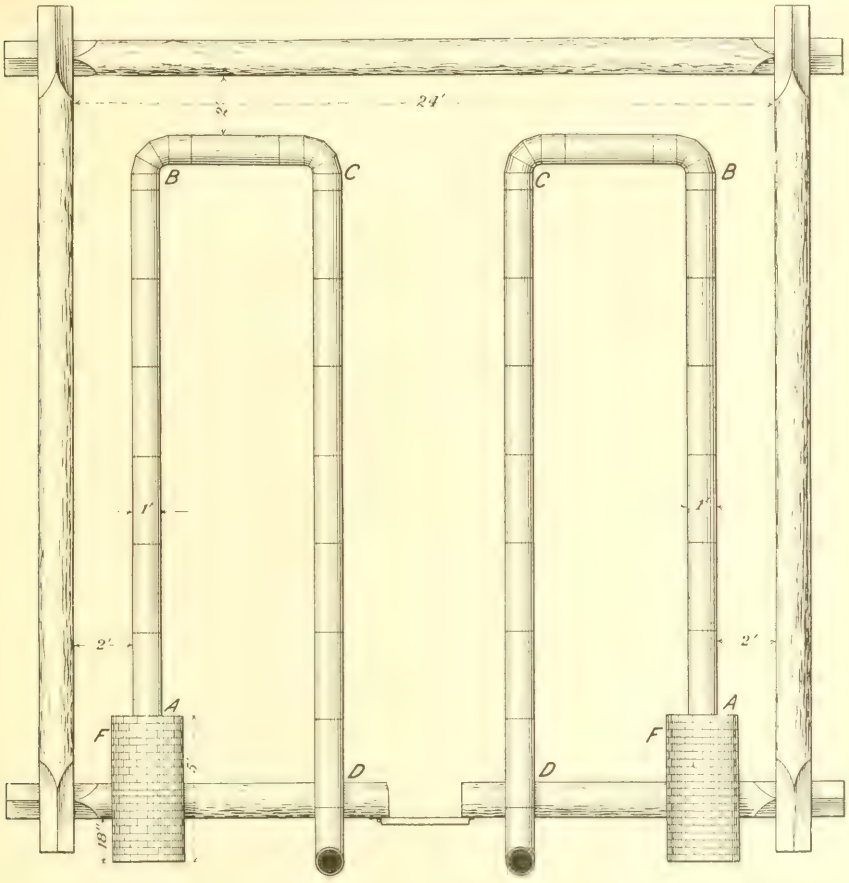


FIG. 9.—Sketch showing the arrangement of furnaces and flues in a barn adapted for curing yellow tobacco: F, F, brick furnaces; A, B, C, D, sheet-iron flues.

stovepiping and are from 10 to 15 inches in diameter. These flues are fitted into the ends of the furnaces at A, A, and extend thence across the barn to B, B, where they turn at right angles and, continuing to C, C, they once more turn at right angles and finally pass outward through the wall at D, D. The flues are slightly inclined upward throughout their length and pass out through the barn wall about 3 feet higher than the mouth of the furnace. A smokestack

3 or 4 feet in height, the upper end of which is provided with a hood, is fitted to the outer end of the flue.

This arrangement of the flues is modified in a variety of ways. The two flues may be united (see fig. 9, C, C), whence a single arm returns to the side of the barn from which the furnaces enter, thus giving three lengths of pipe across the barn instead of four. In the smaller barns a single furnace placed in the center of one end is often made to supply the necessary heat. In this case a single flue leads across the barn and then branches at right angles, each arm returning along the side walls, thus simply reversing the last-described arrangement. Whatever arrangement is used, the flues should in no case be placed within 2 feet of the walls of the barn, and they must, of course, be surrounded with sheet tin or other suitable material at the point where they pass through the wall.

HARVESTING YELLOW TOBACCO.

There are two general methods of harvesting yellow tobacco, in one of which the entire plant is cut, while in the other the leaves are stripped off as fast as they ripen. As a rule, the latter method is generally used in the newer districts, while the practice of cutting the entire plant has many adherents in the older districts. The merits of these two methods of harvesting have already been discussed in Part I (p. 10). Whichever of the two methods is used, the leaf should be riper before housing than is the case with almost any other tobacco. The entire plant should have a yellowish green cast, while the leaf should show numerous flecks of a lighter tint in which the yellow is more pronounced. To obtain the best colors in curing requires that the tobacco be harvested at just the right stage, and here experience and good judgment are essential.

When the method of picking the leaves from the stalk is followed, three or four of the bottom leaves are stripped off at the first harvest. This process is repeated three or four times till all of the leaves have been harvested. The leaves are placed in baskets and hauled directly to the barn or to a temporary brush arbor, which protects them from the sun, and are then hung on sticks. There are two ways of attaching the leaves to the sticks, which are generally cut 4 feet 4 inches in length. In the one case a stout cord is fastened to one end of the stick and drawn into a notch which has been previously sawed in the end of the stick. A few inches from this end the cord is passed once around a bunch of three or four leaves, which will thus hang to one side of the stick. The cord is then drawn to the opposite side of the stick and similarly passed around a second bunch of leaves, the whole process being repeated till the stick is full. Each stick

will thus carry from 20 to 30 bunches, arranged alternately on either side. Another method consists in stringing the leaves on a series of wires, about 10 inches long, which are attached to the stick with small staples at intervals of about 8 inches, as shown in figure 10. These wired sticks carry about the same number of leaves as those on which cord is used. They possess a serious disadvantage in that the tobacco must first be stripped off before it can be bulked down.

When the entire plant is harvested the stalk is first split from the top down to near the bottom leaves and then cut off near the ground. The plants are then inverted and placed astride a stick, each stick receiving 6 to 8 plants. The tobacco is loaded on the wagon in "coops," or square heaps, with the tips of the plants toward the center, or a better way is to haul it to the barn on a rack, such as is shown in figure 4. The sticks are hung from 8 to 12 inches apart on the tier poles.

CURING YELLOW TOBACCO.

The flue-curing process is the only method of curing tobacco in use at the present time which affords the means of controlling the

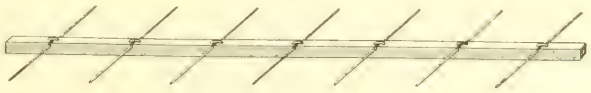


FIG. 10.—Stick with wires used in the yellow-tobacco districts for hanging picked leaves in the curing barn.

temperature and humidity in the barn. The nature of the changes in composition and properties of the leaf which takes place in the process of curing and the relation of temperature and humidity to these changes have been discussed in the first part of this bulletin. A large number of formulas for curing yellow tobacco have been used with more or less success, but the universal experience has been that any formula will require some modification for every curing made. The principal reason for this lies in the fact that all these formulas are based solely on temperature, which is only one factor. To the experienced grower the thermometer is a valuable aid, but the condition of the tobacco is watched as closely as is the thermometer.

The barn should be completely filled in one day, and when this is done a thermometer is hung on the lower tier and near the center of the barn. Small fires are started in the furnaces and a very moderate temperature maintained until the leaf is thoroughly yellowed. During this period, from twenty-four to thirty-six hours, the barn should be kept tightly closed. The yellowing may be accomplished at any temperature between 80° and 120° F., and it is well to start with the lower temperature and gradually raise it up to 110° or 120° F. at the completion of the process.

The completion of the yellowing process ends the first stage of the curing, and then begins the critical period commonly spoken of as "fixing the color." The sole object at this stage is to remove the moisture as fast as it is given off by the leaf, and plenty of ventilation is essential to success. The tobacco should be closely watched, and if particles of water begin to show on the surface of the leaf more ventilation is required. Care should be taken that the temperature does not fall, and the best results are obtained when it is gradually increased throughout this phase of the curing until 130° to 135° F. is reached. If insufficient heat is supplied and, more important still, if there is not ample ventilation, the leaf will redden or "sponge." If the heat is increased too rapidly while the leaf is still full of sap, a greenish black discoloration will develop, which is known as "scalding" or "blistering." The nature and causes of these troubles have been discussed in Part I (p. 24). The remedy lies in a moderate and carefully regulated temperature, together with plenty of ventilation.

The temperature should be maintained at from 130° to 140° F. until the leaf is completely dried out, which will require about ten to eighteen hours after the completion of the yellowing process. All danger from sponging or scalding is now past, and it only remains to dry out the stems. The ventilators are now closed and the temperature raised up to 165° or 170° F. at the rate of about 5 degrees an hour. This latter temperature is maintained till all stems are completely dried out. Some raise the temperature as high as 190° and even 200° F., but this greatly increases the danger of burning up the barn and contents, an accident which is by no means of rare occurrence. When the tobacco is to be taken down the barn is left open during the preceding night so that the leaf may absorb sufficient moisture to bring it into condition for handling. If the leaf can be folded in the hand without breaking the stem it is in proper condition to be taken down without injury.

HANDLING YELLOW TOBACCO AFTER CURING.

When taken down the tobacco is carried to the packing house, where it is bulked down without removal from the sticks. The bulks are built up with all the butts pointing outward and the tips overlapping in the center. The heaps are usually made 4 or 5 feet high and may be of any convenient length. In order to avoid injury from mold the bulks should be torn down at the end of a week and, if desired, rebuilt. This treatment greatly improves the color of the leaf and especially assists in bleaching out the green remaining in the leaf after the curing. It frequently happens that the entire contents of a barn showing a decided greenish cast will come from the bulk with a beautiful clear lemon-yellow color, provided the

green has not been set by drying out the leaf too rapidly in the first stage of the curing.

When the bleaching process has been completed the leaves are carefully assorted into from six to ten grades, based mainly on color and freedom from holes or spots. Yellow tobacco is classified on the market into (1) wrappers, consisting of the most perfect leaves; (2) cutters, leaves deficient in color and inferior to wrappers; (3) smokers, bottom or sand leaves and others bruised or torn and lighter in body than cutters; and (4) fillers, everything not included in wrappers, cutters, or smokers. Each of these four classes is subdivided into two or more grades. The finest grade of wrappers is bright lemon-yellow in color and composed of leaves free from imperfections and possessing sufficient toughness and elasticity. The next best grade is orange-yellow in color, and then comes the light reddish brown grade, known as "mahogany wrappers."

Market prices are greatly influenced by the care and skill used in grading yellow tobacco, and this work requires experience and the ability on the part of the assorter to accurately classify colors. Each grade is tied into small bunches, or "hands," and the leaf is then ready for market. If the market conditions are unfavorable the tobacco may be bulked down and kept in this way until placed on the market.

HEAVY EXPORT TOBACCOS.

The method in use for curing the heavy export type of leaf is a sort of combination of the air-curing and the flue-curing processes, although historically it is perhaps the oldest of all the methods of curing tobacco. The first stage in the curing is carried out without the use of artificial heat, and is therefore identical with the air-curing method, as applied to the cigar and Burley types. In the later stages small fires are kindled on the floor of the barn and the smoke is allowed to pass up through the tobacco, thereby imparting to it a characteristic odor, as well as materially augmenting its keeping qualities.

The old type of barn used for curing export tobacco is very similar to that in general use for curing yellow tobacco. It was built of logs, the cracks being daubed with mud. These barns were small in size, but were generally built high enough to contain five sets of tier poles. In recent years the log barns have been partly replaced by more modern frame buildings of much larger size. These are provided with large doors opening into passageways which lead through the building, thus allowing a loaded wagon to be drawn directly beneath the tier poles. These tier poles are arranged at intervals of about 3 feet 10 inches horizontally and 3 feet vertically, the first set of poles being 8 or 9 feet above the ground.

HARVESTING EXPORT TOBACCO.

The class of heavy export tobacco as a rule matures considerably later than the bright tobacco, owing chiefly to the character of the soil on which it is grown. By allowing it to stand in the field for several weeks after topping there is a decided gain in size and weight of the leaf. When ready for harvesting the leaves droop, they are thick and heavy, mottled with yellow flecks, and break readily when folded between the fingers. As a rule, the plants do not all ripen at the same time, so that it is necessary to make two cuttings. It is not desirable to harvest the tobacco immediately after a heavy rain, for the reason that much of the gummy matter secreted by the leaf is dissolved by the water, resulting in a considerable loss of weight.

In harvesting, the stalk is first split down to within a few inches of the bottom leaves and then severed near the ground. As soon as sufficiently wilted to be handled without breaking the leaves, the stalks are placed astride a stick and are then ready for carting to the barn. The sticks upon which the plants are hung are usually 4 feet 4 inches in length, and each stick carries from six to ten plants, depending on their size. The sticks carrying the plants are piled in squares on the floor of the wagon for hauling to the barn, with the tips of the plants pointing to the center; or a better way is to suspend the sticks on a long rack, as shown in figure 4. They are hung on the tier poles at intervals of from 7 to 10 inches. Some growers prefer to hang the tobacco on scaffolds in the field for several days before housing, in which case the plants are placed closer together in the barn.

CURING EXPORT TOBACCO.

No heat is used for the first three or four days of the curing period, for if applied at this stage the leaf would dry out too rapidly. It is important to avoid this drying out of the leaf before the proper colors have been developed and other important changes effected. In this case the leaf would be starchy and lifeless to the touch, deficient in those substances which impart to it toughness and elasticity. After the third or fourth day slow fires are started on the floor of the barn and the temperature maintained at 90° to 95° F. for about twenty-four hours. This moderate heat greatly facilitates the yellowing of the leaf. As soon as this is accomplished the temperature may be slowly increased till 125° or 130° F. is reached and held at this point till the leaf tissue is pretty well dried out. The fires are then allowed to die out, so that the leaf may again become pliable by the flow of sap from the stalk and stem.

This process of alternate drying out and softening of the leaf is repeated during several weeks, until the stem and leaf are both completely cured. During the first stages of the firing, when the tobacco

is still full of sap, too much heat must be guarded against, else portions of the leaf will be discolored by "scalding," as in the case of flue-curing yellow tobacco. If the tobacco remains hanging in the barn for any considerable length of time after the curing is completed, slow fires should be started during periods of wet weather to prevent injury to the leaf from molds and also to prevent too much darkening of the color. Frequently the tobacco is improved by bulking it down without removing it from the sticks, as already described for yellow tobacco.

HANDLING EXPORT TOBACCO.

When the tobacco after being thoroughly cured has become pliable by the absorption of moisture during a damp season the plants are removed from the sticks and piled in heaps so arranged that all the butts face outward. Beginning at the bottom of the plant the leaves are stripped off and tied into small bundles according to grade. The poorest grade, composed of badly damaged and torn leaves, is known as "lugs." Those leaves which are inferior in color or damaged, but better than lugs, are designated as "seconds," while the remaining sound leaves are classed as "good." These good leaves are further subdivided into several grades, based largely on evenness and depth of color. It is also important to assort the leaves according to size, so that the same bundles shall not contain both long and short leaves. The finest grades are usually put into bundles of only five or six leaves, while the bundles of poorer quality may contain eight or ten leaves.

The profits in growing shipping tobaccos depend in large measure on the skill and care used in assorting and handling the cured product. This class of leaf is sold by sample, and a few badly graded leaves drawn for this purpose will necessarily lower the valuation of the entire lot represented by this sample. Care must also be taken that the tobacco does not contain too much moisture when packed down, for in this case it will be damaged by mold as soon as warm weather sets in. Tobacco offered on the market in this condition will only be taken by those prepared to rehandle it. It is far better to "reorder" such tobacco by again hanging it in the barn until well dried out. It is then ready for taking down again as soon as favorable weather for handling develops. To preserve them in fit condition for packing, the bundles are then bulked down on an elevated platform and the bulks covered with blankets.

In a few weeks after being bulked down the tobacco is packed, or "prized," into large casks. There is much variation in the dimensions of casks used in different localities. The bundles are packed in the hogsheads in closed or cylindrical form instead of spreading out the tips of the leaves, as is done with some types of tobacco. A

screw press is used in packing the casks under the proper pressure. These casks or hogsheads contain from 1,000 to 2,000 or more pounds of leaf, depending on the grades, the best grades being packed in smaller quantities. The casks are transported to the warehouse, where samples are drawn by sworn inspectors under state regulation, and the tobacco is sold at auction.

PERIQUE TOBACCO.

Although produced in relatively very small quantity, the type of tobacco known as "Perique" is specially interesting on account of the peculiar methods used in curing and preparing it for market. It is grown only in St. James Parish, La. On account of the soil and climate in this region, the tobacco grows very rapidly and is harvested in early summer. The plants are cut during the middle of the day and carried directly to the curing shed. They are suspended from ropes by means of short pieces of cane driven into the stalks at an angle near the basal end so as to form a hook.

No artificial heat is used in curing Perique tobacco. As soon as the leaf tissue assumes a brown color the leaves are stripped from the plant before the stems have cured. The leaves are stripped from the plant at intervals of a few days, only three or four being taken at a time. The leafy portion is stripped from the green stems and made into loose rolls which are packed into a small, square box having a capacity of 50 pounds. A pressure of several thousand pounds is brought upon the tobacco in the box and maintained for twenty-four hours. The rolls are then opened out and exposed to the air till the expressed sap has again been absorbed. The tobacco is again placed under pressure and the whole process repeated every twenty-four hours for a period of ten days. After this the manipulation is repeated at increasing intervals for several weeks till the leaf is fully cured and has assumed a black color.

Perique tobacco is generally spoken of as being "cured in its juices," and under this method of curing acquires a peculiarly fine aroma. The sap is repeatedly expressed from the leaf and thereby subjected to the oxidizing action of the air. This affords a completeness of fermentation which is not attained in any of the other methods of curing.

Perique tobacco is assorted into wrappers, fillers, and smokers. To prepare it for market the cured product is put up into 4-pound cylindrical rolls called "carottes." These are prepared by spreading a layer of the leaves, which have been opened out, upon a piece of cloth and covering them with a second cloth. The whole is then rolled into a hollow cylinder and the ends tucked in and tied. A coil of rope is next tightly wound around the roll by means of a windlass and the carotte is then ready for market.

INDEX.

Page.

Air-curing tobacco, effects of heat and ventilation 18–20
process, description of stages 12–22
modifications 21–22
saturation point at different temperatures 20, 23
water capacity at different temperatures 20, 23
Assorting Burley tobacco 40
cigar tobacco 35–36
export tobacco 49
yellow tobacco 47
Barn, tobacco, for curing cigar types, description 27–30
heavy export types, description 48–49
yellow type, description 41–44
heating system for flue-curing 42–44
Barns, tobacco, construction 27–30, 41–44
log, descriptions 42, 47
Bleaching yellow tobacco 46–47
Bulking Burley tobacco 40
cigar tobacco 35
export tobacco 49
yellow tobacco 46–47
Burley tobacco. *See* Tobacco, Burley.
"Carottes," Perique tobacco, preparation 50
Cigar tobacco. *See* Tobacco, cigar.
Color, changes in curing tobacco 8, 13–15, 22–23, 24, 34
fixing in flue-curing yellow tobacco 24, 46
requirements, Burley tobacco 21
different types of tobacco 9–10, 21, 34
cigar tobacco 34
Coloring, tobacco leaf, relation to time of harvesting 9–10
Connecticut Valley, tobacco growing under shade 36
Cuban tobacco. *See* Tobacco, Cuban.
Curing shade-grown cigar-wrapper leaf, management of barn 38–39
tobacco, air process, stages and modifications 12–22
Burley 12–21, 40
changes in composition and properties of leaf 8–9, 13–15, 22–23
cigar 12–21, 33–35, 38
export 48–49
flue process, description and management 22–25
leaves after picking compared to curing on stalk 10–12
Perique 50
practical methods as applied to various types 27–50
principles 7–25
with open fires, description, effects on leaf 25
yellow 41–47

Page.
Cutting tobacco, implements 31
Dampness. *See* Humidity.
Discoloration of tobacco caused by pole-sweat 17
Dryness, injury to tobacco in curing 16, 18, 34
Evaporation, check by humidity, injury to tobacco 17, 19, 20, 34
Export tobacco. *See* Tobacco, export.
Fire-curing tobacco, description and effects on leaf 25
Fires, open, use in curing tobacco 25
Florida, western, shade-tobacco growing 36
Flue-curing process, tobacco, description and management 22–25, 41–46
Flues, tobacco barn, arrangement 42–44
Georgia, southern, shade-tobacco growing 36
Green coloring matter in tobacco, changes in curing 13, 14, 22, 24, 25
Handling export tobacco 49–50
Harvesting Burley tobacco 40
cigar tobacco 30–33
export tobacco 48
Perique tobacco 50
shade-grown cigar-wrapper leaf 36–37
yellow tobacco 44–45
Heat, artificial, application in air-curing tobacco 18–21, 33, 40
Heating system, tobacco barn for flue-curing 42–44
House-burn. *See* Pole-sweat.
Humidity conditions, tobacco curing, control 16, 18–20, 23, 33, 34
injury to tobacco 15, 31
Implements for harvesting cigar tobacco 31–33, 37
Introduction to bulletin 7–8
Kentucky, Burley tobacco growing 39
Leaf, tobacco, coloring, relation to time of harvesting 9–10
composition and properties, changes taking place in curing process 8–9, 13–15, 22–23
curing, comparison with curing on stalk 10–12, 38
texture, relation to time of harvesting 10
tissue, starvation in curing 13, 15
Leaves, tobacco, injury from bruising 13, 17
Log barns for tobacco, description 42, 47
Louisiana, Perique tobacco growing 50
"Lugs," export tobacco, damaged leaves 49
Marketing export tobacco 49
Moisture, effect on color of cured tobacco 14–15
North Carolina, yellow tobacco growing 41
Ohio, Burley tobacco growing 39
Packing Burley tobacco 40
export tobacco 49
Perique tobacco. *See* Tobacco, Perique.
Plug-filler tobacco, production in Virginia 41
wrappers, curing on stalk 12
Pole-sweat, tobacco, causes and conditions for spread 16, 17, 20, 34
organisms, effects 17–18
remedy 18
Priming method of curing tobacco, comparison to curing on stalk 10–12, 38
shade-grown cigar-wrapper tobacco 36
yellow tobacco 44

Page.
Prizing export tobacco 49
Rack, wagon, for harvesting cigar tobacco 32, 37
Reddening leaf tobacco, prevention 24, 25
Ripeness, tobacco, signs 9, 30, 36, 44, 48
Ripening of tobacco, color and texture changes 9–10
Scalding tobacco, cause and avoidance 24, 46, 49
Shade-grown cigar-wrapper leaf, harvesting and curing 36–39
Smoke, effect on tobacco leaf 25
cured tobacco, keeping quality 25
Soils, limestone, adaptation to growing of Burley tobacco 39
yellow tobacco 41
South Carolina, yellow tobacco growing 41
"Splotching" of tobacco, cause and avoidance 24, 46, 49
"Sponging" of tobacco, cause and avoidance 24, 46, 49
Stalk-curing tobacco, comparison with leaf-curing 10–12, 38
Steam heat, application in air-curing tobacco 21
Stringing leaf tobacco, methods 31, 37, 44, 48
Stripping cigar tobacco 35–36
Sumatra tobacco. *See* Tobacco, Sumatra.
Sun-cured tobacco, production in Virginia 21–22, 41
Sweat, cold, in curing tobacco, injury 15
pole. *See* Pole-sweat.
Temperature, control in flue-curing yellow tobacco 24
fatal to life of tobacco 15, 24
tobacco curing, control 15–17, 18–20, 23, 34
Tennessee, Burley tobacco growing 39
yellow tobacco growing 41
Texture, tobacco leaf, changes in curing 8, 13–15, 22–23
relation to time of harvesting 10
Tobacco, air-curing 12–22
barn, heating system for flue-curing 42–44
barns, construction 27–30, 41–44
bright yellow, characteristics of color development 22, 24
Burley, assorting 40
color requirements 21
curing 40
harvesting 40
packing 40
sections where grown 39
cigar, air-curing 12–21, 27–36
color requirements 34
curing 33–35
barn, construction 27–30
harvesting 30–33
injury by humidity 15, 34
ripeness, relation to color 9–10
stripping, assorting, and bulking 35–36
wrapper leaf, shade-grown, harvesting and curing 36–39
color and texture, changes in curing 8, 13–15, 22–23, 24
Cuban and Sumatra, harvesting and curing 36–39
shade-grown, harvesting and curing 36–39
curing picked leaves compared to curing on stalk 10–12
practical methods as applied to various types 27–51

Page.
Tobacco, curing principles 7–25
with open fires 20, 25
export, curing 47–50
grading 49
handling 49–50
harvesting 48
marketing 49
packing 49
prizing 49
flue-curing 22–25
leaf, changes in composition, etc., while curing 8–9, 13–15, 22–23
Perique "carottes," preparation 50
growing, harvesting, curing, and rolling 50
rolls, description 50
ripening, color and texture changes 9–10
shade-grown cigar-wrapper leaf, harvesting and curing 36–39
"strawy" condition, causes 10, 13
stringing 31, 37, 44, 48
Sumatra, shade-grown, harvesting and curing 36–39
sun-cured, production in Virginia 21–22, 41
types, color requirements 9–10, 21, 34
vitality after cutting 11, 13
yellow, assorting 47
bulking and bleaching 46–47
characteristics of color development 22, 24
curing 12, 22–25, 45–46
barn, construction 41–4
growing, soils suitable 41
handling after curing 46–47
harvesting 44–45
Tobaccos, cigar, curing methods 12–21, 27–36
high-priced, priming method of curing 11
Topping tobacco, effect on leaves 9
Ventilation in curing tobacco, humidity, control 18–20, 23, 33, 34
necessity 18–20, 23, 28, 33
Ventilators, tobacco barn, directions for placing 29, 30, 42
Virginia, yellow tobacco growing 41
Water, capacity of air at different temperatures 20
removal from tobacco in curing 15
Weather conditions, tobacco curing, need of control 16, 18, 33
West Virginia, Burley tobacco growing 39
Yellow coloring matter in tobacco, changes in curing 14, 22, 24

143

LIBRARY OF CONGRESS
00009325475